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UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES

PERFORMANCE OF GREEN MANURE SPECIES SEEDED INTO SPRING BARLEY

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With the revival of the small grains industry in the Northeast and the strength of the locavore movement, craft breweries and distilleries have expressed an interest in sourcing local barley for malting. Many farmers are also interested in barley as a concentrated, high-energy feed source for livestock. Depending on the variety, barley can be planted in either the spring or fall, and both two- and six-row barley can be used for malting and livestock feed.

Producers have expressed interest in the best agronomic practices for cultivating spring barley and the use of interseeded cover crops (also known as green manures or living mulches) to increase barley yields and quality. Cover crops grown as living mulches grow with field or row crops to reduce weed pressure, prevent soil erosion, maintain and/or improve soil nutrients, improve soil aggregation, prevent nutrient loss from runoff, and increase water retention. Leguminous living mulches can fix nitrogen and may improve yields and/or quality by adding NO_3 to soil. Varietal selection is very important as living mulches can compete with the main crop. Varieties selected should be shorter than the main crop and shade tolerant. Green manures are typically grown as part of a crop rotation and are plowed under to add nutrients and organic matter to the soil before the main crop is planted.

In this trial, our goals were to evaluate the value of eighteen cover crop treatments both as a living mulch when nterseeded with spring barley, and also their potential as a green manure when their residues are tilled into the soil before planting the next crop in the rotation.

MATERIALS AND METHODS

A field experiment was established at the Borderview Research Farm located in Alburgh, VT on 21-Apr to investigate the ability for green manures to establish in spring barley (variety 'Newdale'). The experimental design was a randomized complete block with four replicates. The plot size was 5'x 20'. The seedbed was prepared by conventional tillage methods (Table 1). The previous crop planted at the site was corn. Prior to planting, the trial area was plowed, disked, and spike tooth harrowed to prepare for planting. The plots were seeded with the Great Plains Cone Seeder on 21-Apr at 125 lbs ac^{-1}. Green manures were broadcast planted by hand on 21-Apr after barley was sown. Seeding rates varied by treatment and are included in Table 2.

Several measurements were taken throughout the growing season. Barley populations were determined by taking three one-foot counts per plot on 17-May. Green manure populations were determined by counting populations in two 0.25 m^2 quadrats per plot on 6-Jun. Barley and green manure heights were recorded on 21-Jul, as well as lodging in the barley plot as assessed by a visual estimate. On 14-Nov, weed biomass and green manure biomass were measured by collecting all biomass in a 0.25 m^2 quadrat per plot. Green manures and weeds were separated and dried.

Barley plots were harvested in Alburgh, VT on 3-Aug and 5-Aug using an Almaco SPC50 small plot combine. Following harvest, grain moisture, test weight, and yield were measured.

Table 1. Agronomic information for spring barley green manure trial, Alburgh, VT, 2016.

Trial Information	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam
Previous crop	Corn
Row spacing (inch)	7
Seeding rate (lbs ac^{-1})	125
Replicates	4
Varieties	Newdale
Planting date	21-Apr
Plot size (ft)	5’ x 20’
Tillage types	Fall plow, spring disk, & spike tooth harrow
Green manure planting	Hand sown 21-Apr
Harvest dates	3-Aug and 5-Aug

Table 2. Green manure treatments and seeding rates.

Green manure	Seeding rate lbs ac^{-1}
Alsike Clover	10
Berseem Clover	15
Crimson Clover	15
Dutch White Clover	10
Ladino Clover	8
Mammoth Clover	10
Medium Red Clover	10
New Zealand Clover	10
Subterranean Clover	20
Italian Ryegrass	25
Perennial Ryegrass	20
Control	0
Chickling Vetch 40 lbs Oats 40 lbs	80
Crimson Clover 12 lbs Italian Ryegrass 8 lbs	20
Ladino Clover 5 lbs Perennial Ryegrass 8 lbs	13
Medium Red Clover 10 lbs Perennial Ryegrass 8 lbs	18
Medium Red Clover 10 lbs Timothy Clover 8 lbs	18
Medium Red Clover 8 lbs Alsike Clover 4 lbs Timothy Grass 8 lbs	20

All data was analyzed using a mixed model analysis where replicates were considered random effects. The LSD procedure was used to separate cultivar means when the F-test was significant (P< 0.10). Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among varieties is real or whether it might have occurred due to other variations in the field. At the bottom of each table a LSD value is presented for each variable (e.g. yield). Least Significant Differences at the 10% level of probability are shown. Where the difference between two varieties within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two varieties. In the following example, variety A is significantly different from variety C, but not from variety B. The difference between A and B is equal to 725, which is less than the LSD value of 889. This means that these varieties did not differ in yield. The difference between A and C is equal to 1454, which is greater than the LSD value of 889. This means that the yields of these varieties were significantly different from one another. The asterisk indicates that variety B was not significantly lower than the top yielding variety.

Variety	Yield
A	3161
B	3886*
C	**4615***
LSD	**889**

RESULTS

Weather data was collected with an onsite Davis Instruments Vantage Pro2 weather station equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT. Temperature, precipitation, and accumulation of Growing Degree Days (GDDs) are consolidated for the 2016 growing season (Table 3). Historical weather data are from 1981-2010 at cooperative observation stations in Burlington, VT, approximately 45 miles from Alburgh, VT.

The growing season this year was marked by lower than normal temperatures in April and temperatures close to the thirty year normal for May, June, and July. There was significantly lower than normal rainfall throughout the growing season, particularly in May and July. Through the barley growing season, there was 5.34 inches of precipitation less than normal. From April through July, there was an accumulation of 3312 Growing Degree Days (GDDs) in Alburgh, which is 41 GDDs less than the 30 year average.

Table 3. Temperature and precipitation summary for Alburgh, VT, 2016.

Alburgh, VT	April	May	June	July
Average temperature (°F)	39.8	58.1	65.8	70.7
Departure from normal	-4.90	1.80	0.00	0.10
Precipitation (inches)	2.60	1.50	2.80	1.80
Departure from normal	-0.26	-1.92	-0.88	-2.37
Growing Degree Days (base 32°F)	291	803	1017	1201
Departure from normal	-98	50	3	4

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

Green Manure Impacts

Barley populations varied significantly by treatment (Table 4). Barley with the New Zealand clover green manure had the highest populations with 298 plants per square meter. This was statistically similar to barley populations with Dutch white clover, ladino clover, mammoth clover, subterranean clover, Italian ryegrass, chickling vetch and oats, medium red clover/alsike clover/timothy grass, and medium red clover/perennial ryegrass green manures, as well as the control barley with no green manure.

Barley height also varied significantly by treatment (Table 4). The tallest treatment (at 67 cm) was the barley planted with the crimson clover green manure. This was statistically similar to the barley planted with alsike clover, berseem clover, Dutch white clover, ladino clover, mammoth clover, subterranean clover, medium red clover/alsike clover/timothy grass, medium red clover/perennial ryegrass, medium red clover/timothy grass, and the control barley with no green manure. Most plots evidenced no lodging. The mammoth clover green manure was the only treatment that was statistically different than the other treatments, with 15% of the barley lodged. However, lodging was observed in only one of the four replicate plots for mammoth clover and was probably unrelated to the green manure treatment.

Green manure populations and heights also varied significantly by treatment, as expected for crops with different growth habits and seeding rates.

Table 4. Impact of green manure on barley and cover crop growth.

	Barley			Green manure	
Treatment	Population	Height	Lodging	Population	Height
	plants m^2	cm	%	plants m^2	cm
Alsike Clover	208	64*	**0***	17	6
Berseem Clover	222	65*	**0***	74*	21
Crimson Clover	222	**67***	**0***	53*	38
Dutch White Clover	237*	63*	5*	52	10
Ladino Clover	231*	62*	**0***	29	8
Mammoth Clover	287*	66*	15	43	11
Medium Red Clover	224	60	**0***	60*	13
New Zealand Clover	**298***	60	**0***	18	6
Subterranean Clover	239*	64*	5*	29	8
Italian Ryegrass	235*	59	**0***	71*	26
Perennial Ryegrass	217	62	**0***	43	17
Control	287*	66*	**0***	-	-
Chickling Vetch/ Oats	287*	61	**0***	7	**76***
Crimson Clover/ Italian Ryegrass	296*	62	**0***	55*	32
Ladino Clover/ Perennial Ryegrass	205	60	**0***	60*	14
Medium Red Clover/ Alsike Clover/ Timothy Grass	267*	62*	**0***	55*	14
Medium Red Clover/ Perennial Ryegrass	296*	64*	**0***	64*	15
Medium Red Clover/ Timothy Grass	203	62*	**0***	65*	14
LSD (0.10)	68	5	9	21	5
Trial Mean	248	63	1.4	44	19

*Treatments with an asterisk are not significantly different than the top performer in **bold**.

Dry conditions through the growing season led to very low moisture at harvest for all treatments (Table 5). The only treatment that was significantly different than the rest in terms of harvest moisture was the chickling vetch/oats treatment, which had the highest moisture content at 9.7%. All treatments also had low test weights. The highest test weight was 41.9 lbs bu^{-1} for the barley with the crimson clover cover crop. This was statistically similar to the berseem clover, mammoth clover, medium red clover, subterranean clover, Italian ryegrass, ladino clover/perennial ryegrass, medium red clover/alsike clover/timothy grass, and medium red clover/perennial ryegrass treatments, and also the control barley with no green manure.

The highest yielding treatment was the medium red clover/perennial ryegrass treatment which produced 3677 lbs ac^{-1} (Table 5). This was statistically similar to the control and all other treatments except the Subterranean clover treatment, which had the lowest yield at 2731 lbs ac^{-1}.

After barley harvest, the amount of weed biomass and the amount of green manure left in field were assessed (Table 5). The highest green manure biomass was the medium red clover at 1407 lbs ac^{-1} on a dry matter basis. This was statistically similar to Italian ryegrass (994 lbs ac^{-1}) medium red clover/alsike clover/timothy grass (1352 lbs ac^{-1}) and medium red clover/perennial ryegrass (985 lbs ac^{-1}). Several treatments did not have any measurable green manure biomass after the barley harvest, including the berseem clover, subterranean, clover and chickling vetch/oat.

The chickling vetch/oats treatment had excellent weed suppression, with no weeds observed in the post-harvest assessment. This was statistically similar to the control treatment (which also had no weed biomass); berseem clover with only 8 lbs of weeds per acre on a dry matter basis; medium red clover and Italian ryegrass, which both had less than 100 lbs of weeds per acre on a dry matter basis; and ladino clover/perennial ryegrass, medium red clover/alsike clover/timothy grass, and medium red clover/perennial ryegrass, which all had 300 lbs or less of weeds per acre on a dry matter basis.

Table 5. Impact of green manure on barley yield and harvest characteristics.

Treatment	Yield @ 13.5% moisture	Harvest moisture	Test weight	Green manure biomass	Weed biomass
	lbs ac^{-1}	%	lbs bu^{-1}	lbs ac^{-1}	lbs ac^{-1}
Alsike clover	3104*	8.1	37.1	200	1355
Berseem clover	3463*	8.1	39.9*	0	8*
Crimson clover	3427*	8.5	**41.9***	181	1248
Dutch White clover	3170*	8.2	37.3	300	689
Ladino clover	3065*	8.0	37.1	160	972
Mammoth clover	3507*	8.0	39.3*	564	629
Medium red clover	3396*	8.0	38.6*	**1407***	94*
New Zealand clover	3454*	8.0	36.9	172	1121
Subterranean clover	2731	8.0	38.4*	0	1360
Italian ryegrass	3283*	8.0	39.0*	994*	76*
Perennial ryegrass	3544*	8.3	37.9	593	660
Control	3481*	8.0	38.8*	0	**0***
Chickling Vetch/ Oats	3634*	9.7	35.3	0	**0***
Crimson Clover/ Italian Ryegrass	3231*	8.3	37.6	182	885

Ladino Clover/ Perennial Ryegrass	3116*	8.1	38.1*	873	308*
Medium Red Clover/ Alsike Clover/ Timothy Grass	3582*	8.1	39.3*	1352*	282*
Medium Red Clover/ Perennial Ryegrass	**3677***	8.3	40.0*	985*	203*
Medium Red Clover/ Timothy Grass	3106*	8.0	36.5	685	711
LSD (0.10)	768	0.6	4	478	550
Trial Mean	3332	8.2	38.3	480	589

*Treatments with an asterisk are not significantly different than the top performer in **bold**.

DISCUSSION

It is important to remember that the results only represent one year of data. The 2016 growing season was ideal for growing spring barley. The warmer than average temperatures along with below normal rainfall throughout much of the growing season resulted in high yields.

While the yields of almost all the barley plots were statistically similar to the control, the average yield for the spring barley green manure trial was 3332 lbs ac^{-1}, all treatments (including the control) except the subterranean clover, performed better than the Newdale barley in the 2016 spring barley variety trial (the Newdale barley in the variety trial had a yield of 2869 lbs ac^{-1}). This difference may not be statistically significant and may be due to small changes in microclimates from one field to the next, but some of the increased yield may have been due to the green manures.

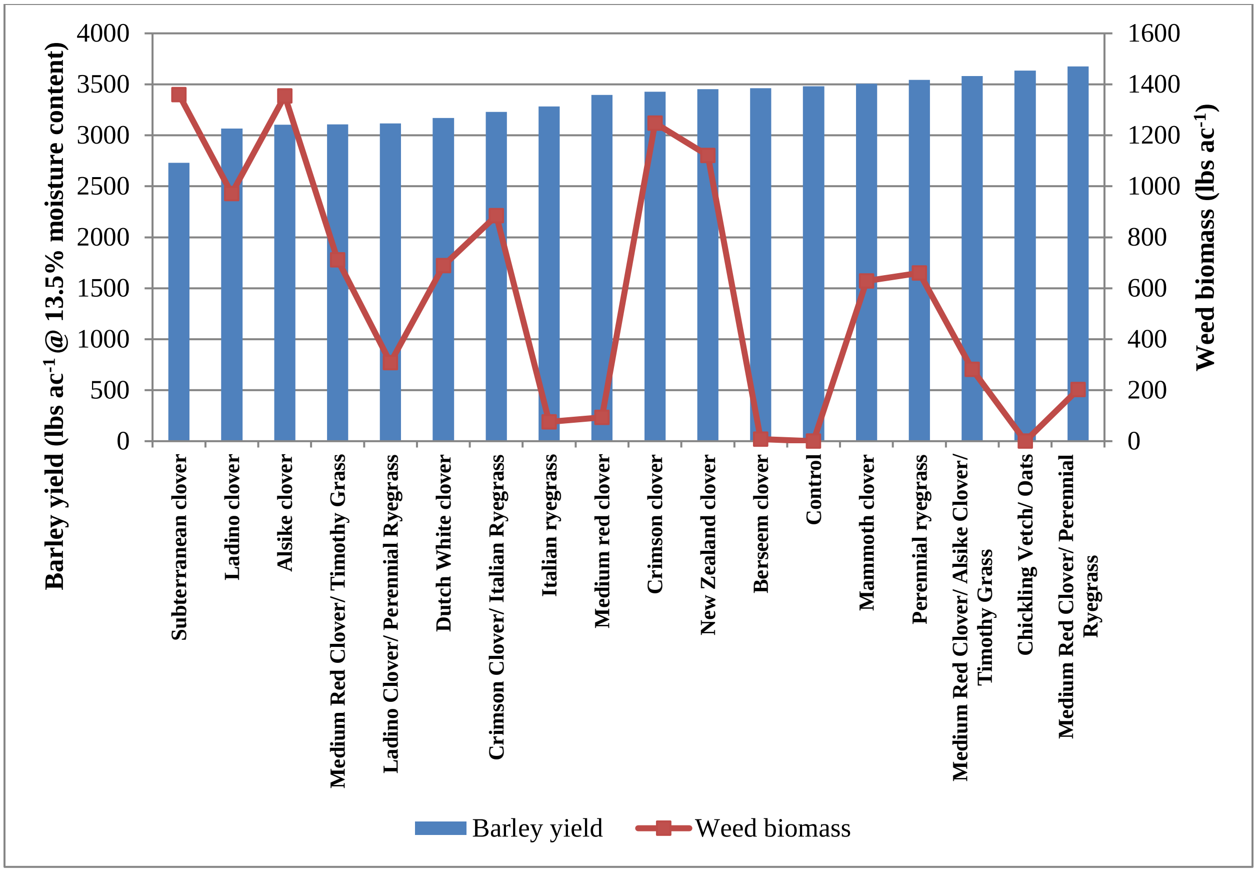

Figure 1. Barley yield and weed biomass for eighteen green manure treatments.

Past research has shown that living mulches in the understory of grains can help reduce weed pressure. In this trial, green manures did not significantly reduce weed pressure compared to the control. The very dry growing season affected weeds nearly as much as crops. While there was not a strong correlation between weed suppression and yield overall (Figure 1), the subterranean treatment had the lowest barley yield and the most weed biomass.

Growing cover crops in the understory of the barley could lead to plant competition for nutrients, water, and other nutrients. Prior research suggests that growing cover crops that are taller than the main crop can increase competition. Only the chickling vetch/oats treatment had taller cover crops than the barley crop on average when heights were measured. This treatment was one of the highest yielding in the study and did not show any evidence of the cover crop competing with the barley. While the average height of the cover crops in treatments containing crimson clover was not taller than the barley height in those plots, it was observed that some of the crimson clover plants were taller than some of the barley. These treatments were also among the higher yielding treatments and evidenced no competition for resources between the tall green manures and the barley.

Several varieties of green manures that had relatively high populations in the summer assessment did not have measurable biomass during the post-harvest assessment. Oats were likely miscounted in both assessments (populations were counted at the tillering stage when oats were difficult to distinguish from barley, and likewise the oats were harvested with the barley). Indeed, many of the taller green manures were underrepresented in the post-harvest assessment because they were harvested with the barley.

This trial was planned to run concurrent with a trial examining all the same 18 green manure treatments in winter wheat. The green manures were frost seeded into winter wheat on 21-Mar 2016. The green manures had very poor establishment. While the wheat grew well (information available in our 2016 Winter Wheat Variety Trial reports), no additional data on the green manures was collected.

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